Week 6 Drilling and Scientific Report for IODP Expedition 357 Atlantis Massif Serpentinization and Life

30th November 2015 – 11th December 2015

This report covers slightly more than a one week period due to the vessel being on transit. Therefore hours indicated in Figure 1 encompass 12 days - <3 operations and the remainder the transit back to Southampton.

1. Hole summary

Hole	M0075B	M0074A
Latitude	30^0 7.65	30^0 9.865
Longitude	42^0 3.97	42^0 7.315
First core	29/11/2015	30/11/2015
Last core	30/11/2015	30/11/2015
Cores recovered	3	1
Drilled length (Coring)	5.702m	2.68m
Drilled Length (Open Hole)	0	0
Recovered length	2.73m	0.86m
Final depth	5.702m	2.68m
Hole recovery	47.88%	32.09%

2. Science

The final week of operations began with RD2 drilling at Hole M0075B (proposal site AM-03) on the eastern edge of the southern ridge of the Atlantis Massif. A technical problem prevented drilling past 5.7 m penetration, and any logging operations. However, a short borehole plug system was inserted into the open borehole. Three cores totalling 2.73 m were recovered (47.9% recovery), consisting of mylonitic to ultramylonitic gabbro. Two whole round core samples were taken from cores 2R and 3R for ephemeral microbiology, geochemistry and contamination testing after fast track multi-sensor core logging, with the rest of the material archived for OSP sampling. Niskin water bottles on the rock drill were collected at the end of drilling for comparative geochemistry and microbiology analyses. A sensor package on the rock drill collected logs of methane, temperature, and dissolved oxygen while drilling.

The technical issues with the RD2 were deemed irreparable in the operation time remaining. An attempt was then made to use MeBo in a modified configuration, consisting of the bottom hole assembly and one core barrel preloaded in the drive; this was the only configuration possible due to the inability to open the chuck drive on the rig following the last deployment. The MeBo drill was deployed at Hole M0074A (proposal site AM-09) with the aim to capture the fault surface on the Massif near IODP Hole U1309D. After coring ended an attempt was made to fire the rock drill Niskin bottles, but two of the three failed to close.

The resulting core consisted of 0.86 m of disturbed and unconsolidated pelagic carbonate sediment, recovered in a split liner. After multi-sensor core logging, sampling was made for ephemeral geochemistry, contamination testing, and microbiology, with the rest of the material archived for OSP sampling. A sensor package on the rock drill collected logs of methane, temperature, and dissolved oxygen while drilling. The tracer delivery system on the MeBo did not operate correctly during this deployment.

Due to ongoing technical problems, neither drill could be deployed again. To fill the remaining time, continued multibeam surveying began over the southern wall of the Atlantis Massif followed by mapping of the eastern conjugate. Following this, a CTD cast was conducted to the east of the Lost City hydrothermal vent field, with one of the methane sensors mounted on the CTD package to provide real time assessment of methane-rich plumes in the water column. Three water depths within the plume of high methane were sampled for ephemeral microbiology and geochemistry.

In summary, in the final week of operations, 3.59 m of core was recovered from two sites, M0075 and

M0074. This brought the total core recovered during Expedition 357 to 57.13 m after 108.939m (including a short open hole section) of total penetration, and with an overall recovery of 52.84% at 17 holes at 9 different sites. Two of these holes, M0069A (proposal site AM-06) and M0076B (proposal site AM-11), north of the Lost City hydrothermal field, were drilled to nearly 16.5 mbsf, with an average core recovery of 71-75%. Such high recovery in shallow mantle sequences is nearly unprecedented in the history of ocean drilling. The MeBo drill delivered 12.49 m of the total rock recovery (21.9%) with the remaining 44.64 m recovered by the RD2 drill (78.1%). The cored sections were highly heterogeneous, ranging from moderately to highly altered and deformed serpentinized peridotites, with varying compositions and occurrences of talc-amphibole schist zones. Less abundant lithologies included lithified basalt breccias, rodingites, and metagabbros with cataclastic to (ultra)mylonitic deformation fabrics. Thus, the cores recovered by seabed rock drilling along the east-west transect across the southern ridge of the Atlantis Massif record an intricate history of deformation, alteration and fluid flow, in which future studies of the recovered material will address many of the major science objectives of the expedition.

In addition to shipboard multi-sensor core logging, a total of 42 whole round core samples were taken during the expedition for ephemeral microbiology, geochemistry and contamination tracer testing, with an additional 10 half- and whole-round samples collected for preparation of thin section billets and bulk rock geochemical analyses that will be available for the on-shore science party. Together, the whole round core samples taken offshore totalled 8.5 m in length (15% of the total recovery; 7.95 m for microbiology and geochemistry, and 0.55 m for thin section billets and bulk rock analyses), with the remainder preserved for studies and sampling at the on-shore science party.

In addition to recovering lower crustal and upper mantle sequences of the detachment fault zone of the Atlantis Massif, advancements in seafloor drill rig technology were achieved during Expedition 357. For the first time, two borehole plug systems were successfully installed by the RD2 drill (Holes M0072B and M0075B), with two other attempts made of unknown success (Holes M0068B and M0071B). These borehole packers will enable future sampling of formation fluid from the boreholes to understand geochemical and microbiological processes in this actively serpentinizing system. During RD2 operations, the functionality of the new magnetic susceptibility logging tool was tested, and four through-pipe logs were collected with the optical acoustic gamma ray memory logging tool; one pass with the MeBo's spectral gamma ray tool was also conducted through pipe. Unfortunately, no open-hole logging operations could be conducted during the expedition due to failure to create appropriate open-hole conditions for logging during drilling operations. The sensor packages designed for this expedition were highly successful and consistently delivered real-time chemical information while drilling, allowing *in situ* confirmation of ephemeral events such as gas release during penetration. Finally, a new pump system was proven to deliver a geochemical tracer during drilling for contamination tracer testing.

To supplement drilling operations and fill operational downtime, we conducted extensive water column sampling during the expedition to provide background samples for comparative microbiology and geochemistry to the core samples. Twelve casts of the ship's CTD Niskin bottle rosette were made around the Atlantis Massif and in the nearby Mid-Atlantic Ridge and Atlantis Fracture Zone, collecting 91 water samples in total. Bottom water concentrations of hydrogen varied across the Atlantis Massif, indicating zones of active serpentinization that will be correlated to rock core samples. Four surface water samples were collected with a bucket prior to recovery of drill rigs after drilling to account for potential ship-induced contamination of the core samples during recovery. Finally, 35 water samples were collected from the rockdrill-mounted Niskin bottles connected to the sensor packages. In total, 445 L of water were collected during the expedition.

The ship's multibeam system was also used during operational down time to collect a higher resolution (20-50m pixel size) bathymetric data of the Atlantis Massif, the neighbouring sections of the Atlantis Fracture Zone and Mid-Atlantic Ridge, and the conjugate to the east of the Mid-Atlantic Ridge.

3. HSE Activity

N/A

4. Figures

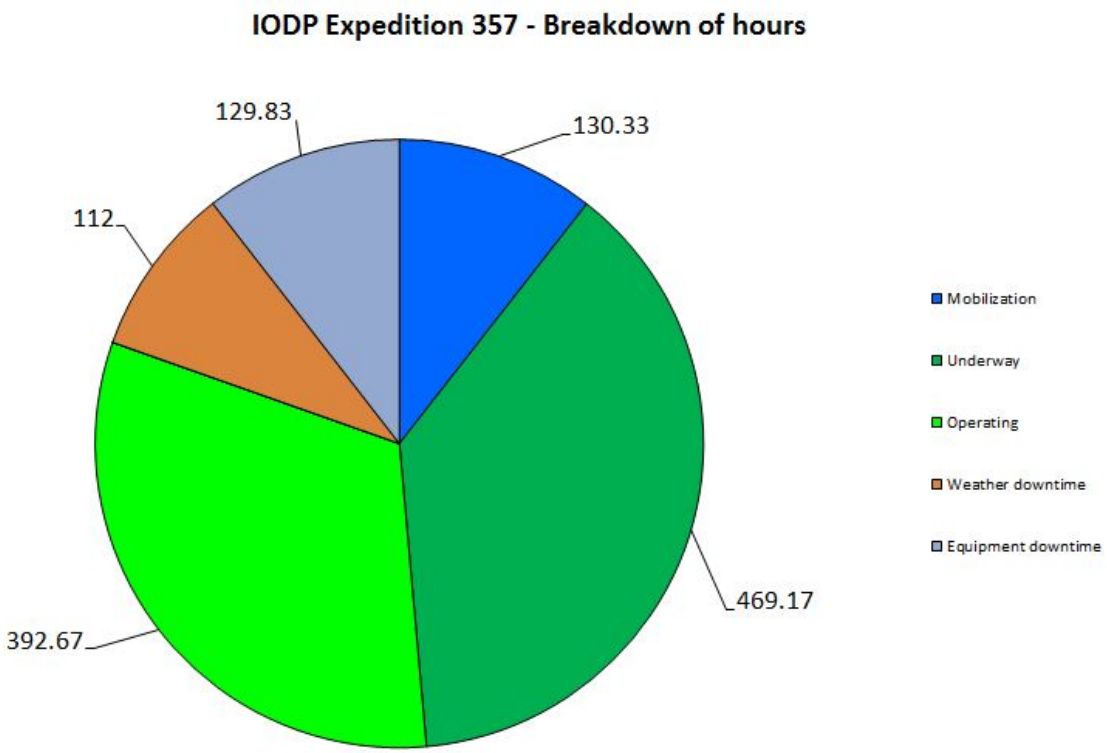

Figure1: Breakdown of hours from the start of mobilisation to coming alongside in Southampton on December 11th.

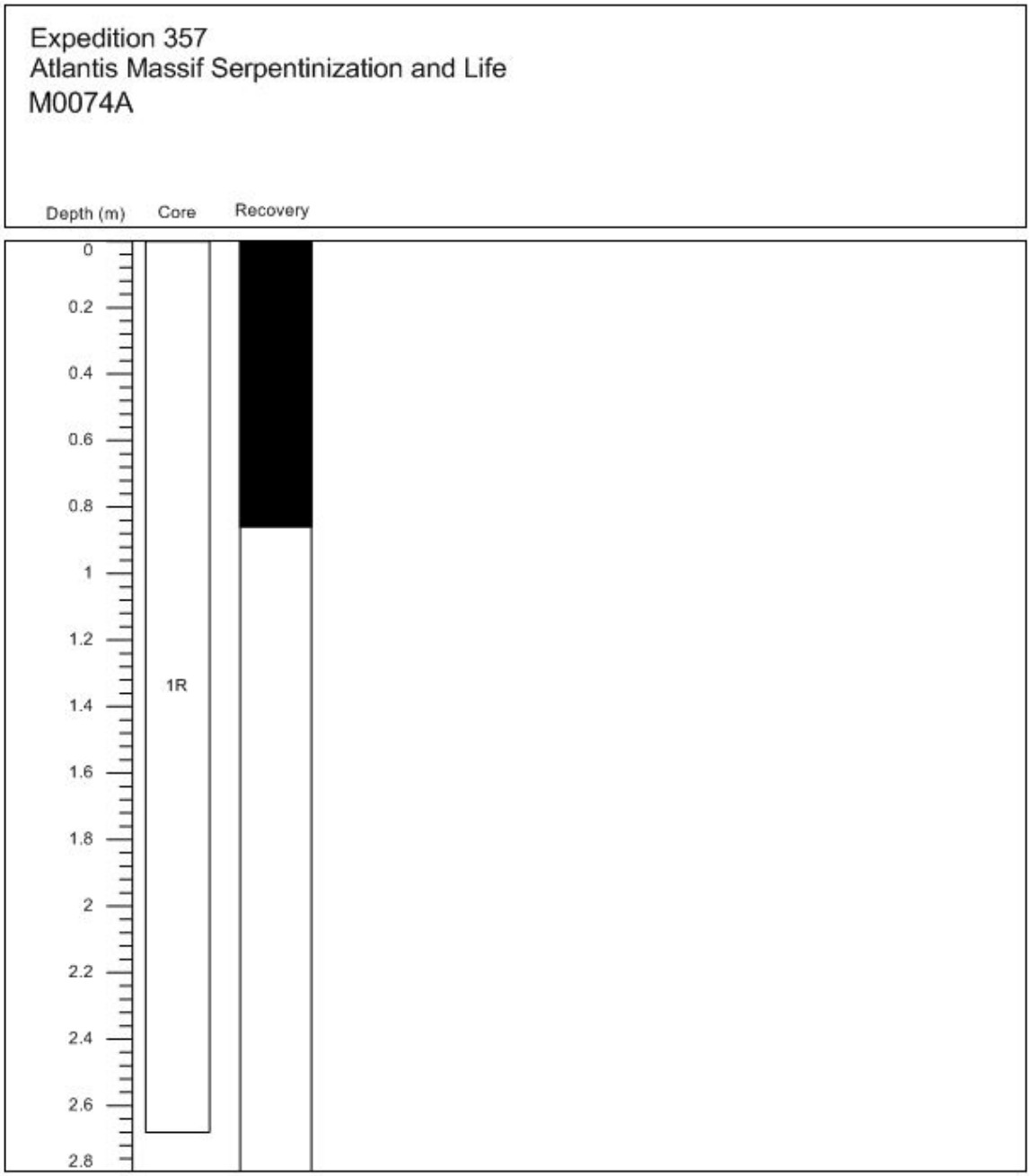

Figure 2: Core runs and recovery (Black shading) for site AM-09A, M0074A.

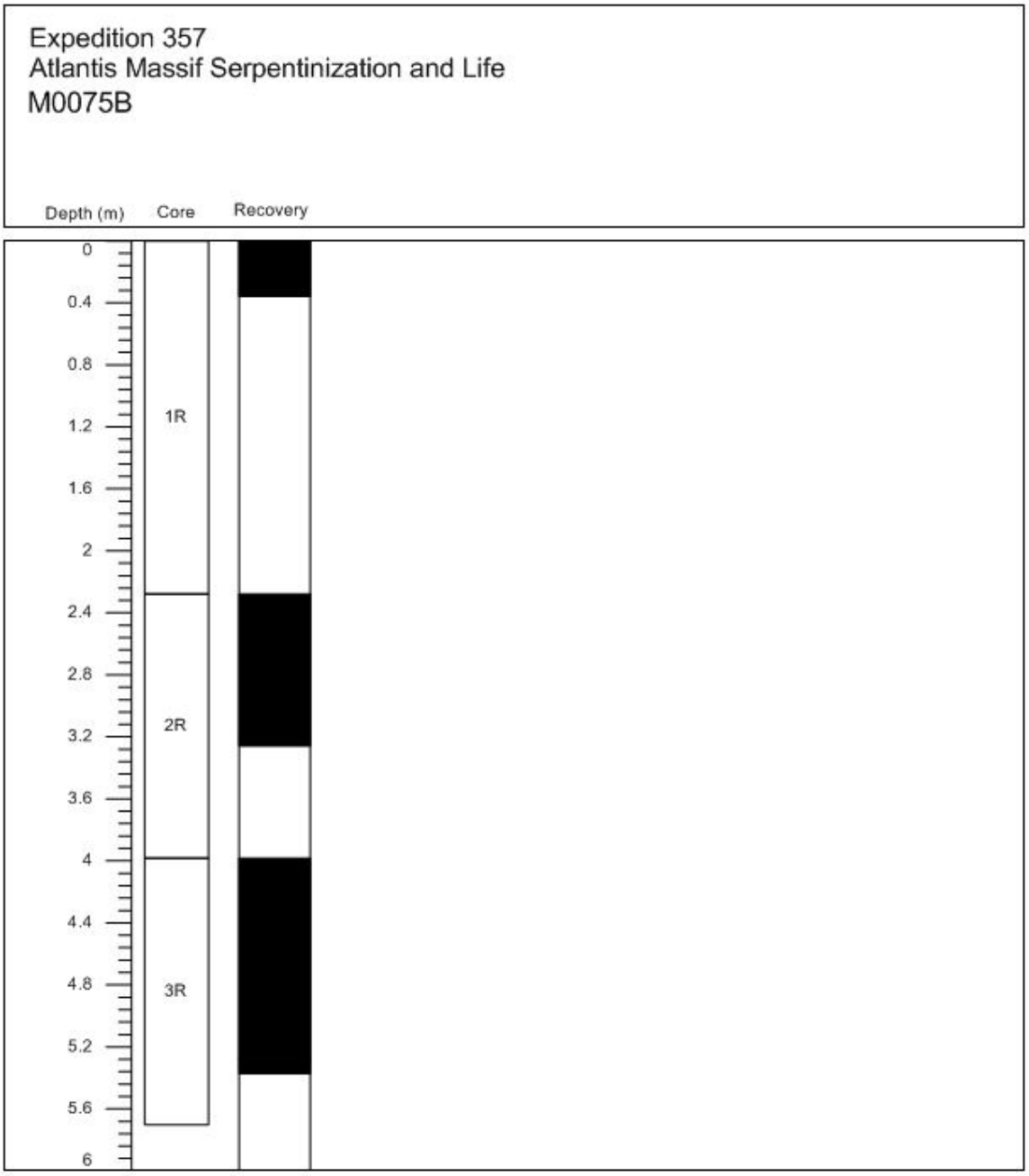

Figure 3: Core runs and recovery (Black shading) for site AM-03A, M0075B.

MSP Hole Identifier	Prospectus Identifier	Number of Cores	Interval Cored (m)	Core Recovered (m)	Core Recovery (%)	Interval open holed (m)	Penetration depth CSF-A (mbsf)
M0068A	AM-02A	1	1.965	0.47	23.9	0	1.965
M0069A	AM-06A	10	16.44	12.29	75	0	16.44
M0070A	AM-07A	3	4	2.09	52.25	0	4
M0071A	AM-04A	2	5.22	2.85	54.6	0	5.22
M0072A	AM-01A	2	2.225	0.87	39.1	0	2.225
M0072B	AM-01A	8	11.603	6.49	52.3	0.825	12.428
M0070B	AM-07A	1	1.3	0.38	29.23	0	1.3
M0073A	AM-05A	1	2.2	0	0	0	2
M0076A	AM-11A	1	1.72	0.4	23.26	0	1.72
M0076B	AM-11A	10	16.31	11.71	71	0	16.31
M0071B	AM-04A	3	4.3	2.31	53.62	0	4.3
M0070C	AM-07A	3	5.21	2.21	42.42	0	5.21
M0068B	AM-02A	10	9.6	6.34	66.04	0	9.6
M0071C	AM-04A	9	12.15	4.48	30.29	0	12.15
M0075A	AM-03A	1	1.72	0.65	37.79	0	1.72
M0075B	AM-03A	3	5.7	2.73	47.88	0	5.7
M0074A	AM-09A	1	2.68	0.86	32.09	0	2.5

Table 1: Summary of all holes cored during Expedition 357.